High-Temperature Negative Differential Resistance in Tungsten Diselenide Multilayers without Heterojunctions

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Various exotic functional electronics devices have been proposed to address the limitations of conventional complementary metal oxide semiconductor devices. Negative differential resistance (NDR) devices have been integrated with heavily doped n-type and p-type channel layers to form heterojunctions. However, undesired interfacial defects are unavoidable during heterojunction formation, and the selection of appropriate materials for type-III gap formation is constrained by the requirement for a desirable band alignment. Herein, we report the presence of NDR in WSe_2 multilayers without heterojunctions under high electrostatic drain and gate bias conditions of up to a temperature of 450 K. The peak-to-valley current ratio (PVCR) is approximately 1.2 at room temperature indicating enhanced thermal perturbation and carrier-carrier scattering. Despite an increase in the activation energy in deep metallic regimes, the observed NDR can be primarily attributed to the self-heating effect rather than band-to-band tunneling. To further exclude undesired oxide trap effects originating from SiO_2 on NDR, hexagonal boron nitride is employed as the supporting dielectric substrate with different channel lengths, achieving a PVCR of ≈2.3 with a maximum peak current of ≈58.4 μA/μm at room temperature. These findings promote the development of NDR-based multi-valued logic devices for next generation data processing and storage. Furthermore, based on these results, we successfully demonstrated an NDR-based multi-valued logic device for next-generation data processing and storage, as evidenced by voltage transfer characteristics, exhibiting distinct multilevel states.

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References

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Figures

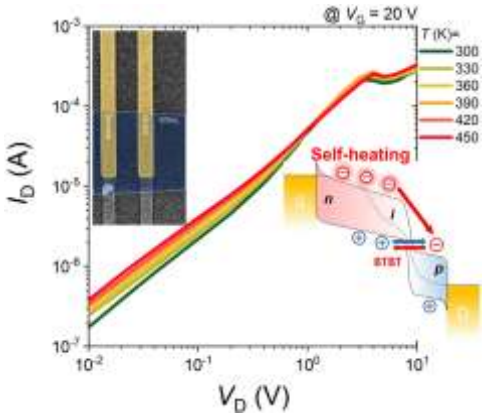

Figure 1: High-temperature WSe_2 NDR transistors enabled by self-heating